Update on Inpatient Diabetes Management
ICU Care

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Disclosures

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• Honoraria: UpToDate, Elsevier, CMHC, ACHL
Outline

• Background
• DKA
• IV Insulin
• Glucose Monitoring

Prevalence of Diabetes in the Hospital

• 23% of all discharges
  – Higher LOS
  – Greater costs
  – More comorbidities
  – ~20% (1.7-1.9 million) are early readmissions with annual cost: $25 billion

CDC’s Division of Diabetes Translation. Available at: www.cdc.gov/diabetes/statistics/dmany/fig1.htm
https://www.cdc.gov/diabetes/home/index.html
Available at: http://hcupnet.ahrq.gov/HCUPnet.jsp
Diabetes Hospitalizations

- In 2016, there were 7.8 million hospitalizations among patients with Dx code for DM\(^1\)
- DM or hyperglycemia associated with greater\(^2\)
  - Costs
  - LOS
  - Mortality
  - Complications
  - Readmissions

Age-adjusted diabetes-related preventable hospitalizations

<table>
<thead>
<tr>
<th>Hospitalization rate %</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

- Data extrapolated from National Inpatient Sample

2. Dhatariya et al. www.endotext.org

Isn’t Hyperglycemia just an adaptive response to stress?

- Treatment Factors
  - Exogenous glucocorticoids
  - Vasopressors
  - Total parenteral nutrition
  - Enteral nutrition

- Illness Factors
  - Catecholamines
  - HPA axis activation
  - Inflammatory cytokines
  - Lipotoxicity

- Patient Factors
  - Pancreatic reserve
  - Insulin resistance

- Acute illness
- Decreased immune function
- Decreased wound healing
- Increased oxidative stress
- Endothelial dysfunction
- Increase in inflammatory factors
- Procoagulant state
- Increased nitrogen levels
- Fluid shifts
- Electrolyte fluxes
- Potential exacerbation of myocardial and cerebral ischemia

Inzucchi NEJM 2006;355(18):1903
What should be the Target Glucose Range?

- **80-110 mg/dl**
  - Too much hypoglycemia
  - May increase mortality

- **110-140 mg/dl**
  - High risk populations? (CT surgery)
  - May be appropriate at some institutions

- **140-180 mg/dl**
  - Multi-center study data
  - Acceptable range until further data

- **>180 mg/dl**
  - Fluid and electrolyte shifts
  - Impaired immune function

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Risk Factors for Hypoglycemia--ICU

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>2.6</td>
<td>1.5-4.7</td>
</tr>
<tr>
<td>Sepsis</td>
<td>2.2</td>
<td>1.2-4.1</td>
</tr>
<tr>
<td>CVVHD</td>
<td>3.7</td>
<td>1.6-8.6</td>
</tr>
<tr>
<td>↓CHO</td>
<td>6.6</td>
<td>1.9-23</td>
</tr>
<tr>
<td>Insulin prior to admit</td>
<td>17</td>
<td>2.3-127</td>
</tr>
<tr>
<td>Insulin use</td>
<td>5.4</td>
<td>2.8-10</td>
</tr>
<tr>
<td>Shock</td>
<td>1.8</td>
<td>1.1-2.9</td>
</tr>
<tr>
<td>Prior Hypoglycemia</td>
<td>2.3</td>
<td>1.1-4.7</td>
</tr>
</tbody>
</table>

Reduce insulin, increase monitoring if
- Any form of carbohydrate is interrupted
- Declining renal or hepatic function


AACE/ADA CONSENSUS STATEMENT ON INPATIENT GLYCEMIC CONTROL; Endocr Pract 2009;15(4)
ADA Standards of Care:Diabetes Care 2021
Endocrine Society Guidelines 2013
Consensus Definition of Ketoacidosis

- Consensus: ADA, AACE, AADE, Endocrine Society, JDRF, Pediatric Endocrine Society, T1D Exchange
  - Urine/serum ketones >ULN
  - Bicarb <15 mmol/l or pH <7.3
  - AG not included
  - Does not account for acidosis from other causes

Risk Factors for DKA

- Retrospective cohort

<table>
<thead>
<tr>
<th></th>
<th>First DKA N=73</th>
<th>Recurrent DKA N=91</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>41</td>
<td>41</td>
<td>0.71</td>
</tr>
<tr>
<td>BMI</td>
<td>29</td>
<td>26</td>
<td>0.05</td>
</tr>
<tr>
<td>DM duration</td>
<td>9.5</td>
<td>14.3</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Homeless</td>
<td>6.9%</td>
<td>23%</td>
<td>0.005</td>
</tr>
<tr>
<td>Insured</td>
<td>26%</td>
<td>48%</td>
<td>0.01</td>
</tr>
<tr>
<td>Follows in DM clinic</td>
<td>27%</td>
<td>67%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Prior DM Education</td>
<td>56%</td>
<td>84%</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>H/o depression</td>
<td>28%</td>
<td>42%</td>
<td>0.03</td>
</tr>
<tr>
<td>Alcohol</td>
<td>25%</td>
<td>40%</td>
<td>0.047</td>
</tr>
<tr>
<td>Illicit substance</td>
<td>23%</td>
<td>52%</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>A1c</td>
<td>12.4%</td>
<td>12.1%</td>
<td>0.21</td>
</tr>
</tbody>
</table>

Randall et al. Dia Care 2011;34:1891-1896
Agiostratidou et al. Dia Care 2017;40(12):1622-1630
**Reasons for stopping insulin**

“Because most people learn best through repetition, diabetes education should be repeated at least yearly, with review of basic concepts and additional supplemental concepts as well as checks for understanding and modifications for patients with recurrent DKA.”

Randall et al. Dia Care 2011;34:1891-1896

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**Pathogenesis of DKA**

- Absolute Insulin Deficiency
  - Lipolysis
  - Ketogenesis
  - Ketoacidosis
- ↑Counterregulatory Hormones
  - Glucose utilization
  - Proteolysis
  - Proteolysis
  - Gluconeogenesis
  - Hyperglycemia
  - Osmotic diuresis
  - Dehydration
- Relative Insulin Deficiency
  - Glycogenolysis
  - Hyperosmolarity
  - HHS

Diabetes Care 2009 Jul; 32(7): 1335-1343
DKA with SGLT2 inhibitors in patients with T2D

• Risk of DKA increased with SGLT2i ~2.2-2.5-fold\(^1\)
• Mechanism:
  ‒ Reduced ketone clearance
  ‒ Glycosuria→\textit{euglycemic} DKA
  ‒ Natriuresis
  ‒ \(\uparrow\text{glucagon}\→\text{lipolysis}\)

Criteria for holding dose:\(^2\)
  • Symptoms consistent with DKA
  • Fasting/inability to eat
  • Dehydration
  • Unusual physical activity
  • Excess EtOH use
  • Hospitalization/procedures (hold 3 days prior)

\(^1\) Fralick et al.  N Engl J Med 2017;376(23):2300-02

DKA 2-bag Method

• Maintains constant fluid, electrolyte and insulin infusion while titrating 1 bag with dextrose and 1 without in response to changing BG
• Associated with
  ‒ Earlier resolution of DKA\(^1,2\)
  ‒ Less waste of partially used fluids\(^1\)
  ‒ Possibly less hypoglycemia\(^2\)

When to initiate: 3 consecutive BG >200 mg/dL
Target: 120 - 150 mg/dl

- Serum or capillary glucose q1hour.
- Dextrose at 10 ml/hour during infusion.
- Initiate infusion at 2 units/hour.
- Rate of decline of glucose should be <100mg/dl/hour.
- If patient is eating, administer SQ rapid acting insulin.
- Hypoglycemia alone does not justify prolonged cessation.

### Table 1. IV Insulin Infusion

<table>
<thead>
<tr>
<th>Current Glucose</th>
<th>Change in Glucose from Prior Measure</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 400 mg/dL</td>
<td>Increased by 1 unit/hour</td>
</tr>
<tr>
<td>301-400 mg/dL</td>
<td>Increased by 2 unit/hour</td>
</tr>
<tr>
<td>201-300 mg/dL</td>
<td>Increased by 3 unit/hour</td>
</tr>
<tr>
<td>151-200 mg/dL</td>
<td>Increased by 4 unit/hour</td>
</tr>
<tr>
<td>120-150 mg/dL</td>
<td>Optimal</td>
</tr>
<tr>
<td>80-120 mg/dL</td>
<td>Increase by 1 unit/hour</td>
</tr>
<tr>
<td>&lt; 80 mg/dL</td>
<td>Increase by 2 unit/hour</td>
</tr>
</tbody>
</table>

Determinants of insulin adjustment:
- Change in BG
- Direction of change in BG
- Current BG
- Current infusion rate

Separate Guidelines: Differ in aggressiveness
Type 1 Diabetes/DKA
Type 2 Diabetes/Other Hyperglycemia

Contact the prescriber.
Increase infusion rate according to the row for 301-400 mg/dL.
If glucose is >400 mg/dL, and the decline in glucose is >25 mg/dL per hour for two consecutive glucose checks, consider doubling the rate of infusion.

Computerized algorithms

- May be integrated within EMR
- Learns patient insulin sensitivity
- Built-in meal boluses
- Fewer fingerstick BG, more timely
- Less nursing judgement, time, more satisfaction
- Meta-analysis (13 studies) vs. paper algorithm
  - ↓ mean glucose -23.74, (95% CI: -24.45 - -23.02), p <0.00001
  - ↑ % of time in target.
  - ↓ hyperglycemia (1.3 ± 1.2% vs 6.5 ± 2%, p<0.05).


Physiologic Insulin Regimen

3 Components

<table>
<thead>
<tr>
<th></th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Basal</strong></td>
<td>Long-acting insulin analogue</td>
</tr>
<tr>
<td></td>
<td>NPH</td>
</tr>
<tr>
<td></td>
<td>Continuous SQ rapid acting insulin</td>
</tr>
<tr>
<td></td>
<td>analogue (pump)</td>
</tr>
<tr>
<td></td>
<td>IV insulin drip</td>
</tr>
<tr>
<td><strong>Prandial</strong></td>
<td>Rapid-acting insulin analogue</td>
</tr>
<tr>
<td></td>
<td>Regular insulin (tube feeds)</td>
</tr>
<tr>
<td><strong>Correction</strong></td>
<td>See prandial insulin</td>
</tr>
<tr>
<td>(supplemental)</td>
<td>IV insulin drip</td>
</tr>
</tbody>
</table>

Rapid acting insulin analogues: Aspart (Novolog), Lispro (Humalog), Glulisine (Apidra); Long acting insulin analogues: glargine (Lantus), detemir (leemir)
**Conversion to SQ Insulin**

<table>
<thead>
<tr>
<th>Patient ready to transition off IV insulin</th>
<th>4-6 hour basal insulin overlap</th>
<th>Stop IV Insulin Stop dextrose</th>
</tr>
</thead>
</table>

**IV insulin**

**Dextrose**

**Basal insulin**

Basal insulin dose = Average infusion rate $\times 15$

2 unit/hr $\times 15 = 30$ units

- Assumes that the drip is not being used for meal coverage
- Compare to home dose of insulin and weight-based needs

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**Tube Feeds Possible Approaches:**

<table>
<thead>
<tr>
<th>Continuous TF</th>
<th>Overnight TF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basal Insulin</td>
<td>&lt;50% of TDD (basal insulin not always necessary)</td>
</tr>
<tr>
<td>Regular</td>
<td>50-100% of TDD divided evenly Q6hr</td>
</tr>
<tr>
<td>NPH (optional)</td>
<td>30 min prior to start of TF</td>
</tr>
<tr>
<td>Correction dose regular insulin</td>
<td>prn Q6hr</td>
</tr>
</tbody>
</table>

**Anticipatory orders are crucial:**

- Hold if TF stop or anticipated to stop within 6 hours of dose
- Hold if BG <100
- If unanticipated TF cessation: check BG Q1hr x 6hr and start D5 at same rate TF were running until TF restart or 6 hours after last dose of regular insulin
COVID-19 Inpatient DM Algorithms

ICU
- DKA/HNK or Refractory Hyperglycemia
- IV insulin* + hybrid Dexcom/POC
- Glargine BID
  - TF: Reg. Q6h
  - Dex: Reg Q6hr
  - POC BG Q6hr
- T2D, T1D or Hyperglycemia
  - *IV pump outside of patient room
  - POC BG and insulin dose should coincide with standard administration times
  - Tray delivery, POC BG, and insulin dose all at once

Non-ICU
- Mild-moderate DKA
- Mild-moderate Hyperglycemia
  - TDD <200 mg/dl
  - TDD <0.6 unit/kg
- Moderate-severe Hyperglycemia/T1D
  - Glargine
  - Lispro Q4h
  - POC BG Q4h
- Awake/alert

- Glargine
- Lispro Q12h
- POC BG Q12h
- Low carb diet
- Glargine
- Lispro QACHS
- POC BG QACHS
- Self-administration
- Home BG/Freestyle Libre

Open Access Initiative: www.covidindiabetes.org

Continuous Glucose Monitoring

- Physiologic Lag 10-15 min between blood and interstitial fluid
- Inaccuracy at low BG, rapid glucose swings
- Home BG devices not approved in hospital—exceptions for COVID
- ICU data:
  - Small studies
  - Variable accuracy, not tested over robust glucose ranges
  - Acceptable safety, modest effect on glucose control
  - Reduce nursing workload

What about a hybrid strategy using POC BG and CGM?

Can a Hybrid BG and CGM Model be used safely in the ICU?

<table>
<thead>
<tr>
<th>Stage</th>
<th>POC Glucose Testing Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial CGM Validation</td>
<td>Proceed to Q6 hour POC testing when 2 consecutive hourly POC readings meet criteria:</td>
</tr>
<tr>
<td></td>
<td>1. CGM within 20% of POC (POC &gt; 100 mg/dl)</td>
</tr>
<tr>
<td></td>
<td>2. CGM within 20 mg/dl of POC (POC &lt; 100 mg/dl)</td>
</tr>
<tr>
<td>Ongoing Validation</td>
<td>• Revert from Q6 hour to Q1 hour POC if any CGM value does not meet the validation criteria</td>
</tr>
<tr>
<td></td>
<td>• Obtain 1 time POC glucose if:</td>
</tr>
<tr>
<td></td>
<td>1) No CGM value</td>
</tr>
<tr>
<td></td>
<td>2) No trend arrow</td>
</tr>
<tr>
<td></td>
<td>3) Urgent low soon or low threshold alert</td>
</tr>
<tr>
<td></td>
<td>4) Signs and symptoms do not match glucose readings</td>
</tr>
<tr>
<td></td>
<td>5) Change in clinical status, such as intubation, hemodynamic compromise, or change in nutrition</td>
</tr>
<tr>
<td></td>
<td>6) New sensor</td>
</tr>
</tbody>
</table>

Mitigation of Risk:
- Sensor validation
- Alert threshold 100 mg/dl
- Predictive alert
- Continuous data
- Clinical context
- Diabetes consult

Not FDA approved

High level results
- 19 patients, Vent: 89%, Vasopressor: 37%, Dialysis: 42%
- Median time to validation: 137 min (IQR 114, 206)
- MARD: 13.9—no apparent effect of O2 sat, MAP, vasopressor, renal replacement, anticoagulation, vent support
- TIR (70-180 mg/dl)
  - Day 1: 64±23%
  - Day 2-7: 72±16%
- TBR (70 mg/dl)
  - Day 1: 1.5 +/-4.1%
  - Day 2-7: 0.16 +/- 0.35%

![Graph showing POC BG, CGM values recorded in EMR, and CGM values for titration](image)
Initial treatment of diabetic ketoacidosis in the emergency department

Minimizing blood loss in patients getting hourly blood glucose tests
Inpatient Diabetes Management in the Non-ICU Setting

Roger Harty, MD
Assistant Professor - Clinical
Division of Endocrinology, Diabetes & Metabolism
The Ohio State University Wexner Medical Center

Outline

• Background
• Target Glucoses
• Inpatient Therapy
• Hospital Discharge Planning
Prevalence of Diabetes in the Hospital

- Diabetes
  - 34.2 million people have diabetes (10.5% of the US population)
- Prediabetes
  - 88 million people aged 18 years or older have prediabetes (34.5% of the adult US population)
- 23% of all hospital discharges
  - Higher length of stay
  - ~20% (1.7-1.9 million) are early readmissions with annual cost: $25 billion

CDC’s Division of Diabetes Translation. Available at: www.cdc.gov/diabetes/statistics/dmany/lg1.htm
https://www.cdc.gov/diabetes/home/index.html

What should be the Target Glucose Range?

80-110 mg/dl
- Significant hypoglycemia
- Possible risk of increased mortality

110-140 mg/dl
- Consider for High risk populations (CT surgery)

140-180 mg/dl
- Acceptable range until further data available

>180 mg/dl
- Associated with fluid and electrolyte shifts
- Impaired immune function

AACE/ADA CONSENSUS STATEMENT ON INPATIENT GLYCEMIC CONTROL; Endocr Pract 2009;15(4)
ADA Standards of Care Diabetes Care 2019
Endocrine Society Guidelines 2013
- The preferred treatment for non-critically ill patients is a basal plus bolus correction regimen.
- For those with good nutritional intake carbohydrate coverage should be added as well
Determining Insulin Dosing

Total Daily Insulin Dose = (0.3-0.5 units/kg)(Total body weight in kg)

Typically half of the total daily dose is given as a basal insulin (0.15-0.25 units/kg)

Typically the remaining half is given as mealtime/bolus coverage if the patient is felt to be a candidate for bolus coverage

Basal Insulin Initiation in Patients not Receiving IV Insulin Therapy

<table>
<thead>
<tr>
<th></th>
<th>Insulin naïve</th>
<th>Not insulin naïve</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age &gt;70 years +/-</td>
<td>0.1-0.15 unit/kg</td>
<td>Evaluate based upon home medication adherence, home BG trends, A1c on admission, current oral intake, additional factors (such as renal function)</td>
</tr>
<tr>
<td>GFR &lt; 60 ml/min</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BG between 140-200 mg/dL</td>
<td>0.20 units/kg</td>
<td></td>
</tr>
<tr>
<td>BG &gt; 200 mg/dL</td>
<td>0.25 units/kg</td>
<td></td>
</tr>
</tbody>
</table>

Endocrine Society Guidelines 2012
Basal Insulins

- Therapeutic interchange:
  - Glargine U100 → U300: 1:1
  - Glargine U300 → U100: decrease dose 20%
  - Degludec → other: 1:1, consider dose reduction

<table>
<thead>
<tr>
<th>Preparation</th>
<th>Onset</th>
<th>Peak</th>
<th>Duration</th>
<th>Vial</th>
<th>Dosing Range per injection (Unit)</th>
<th>Dosing Increment per Injection (Unit)</th>
<th>Dispensing Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPH Daily or BID</td>
<td>1-2 hr</td>
<td>4-8 hr</td>
<td>10-20 hr</td>
<td>10 mL, 1000 unit</td>
<td>Kwikpen: 1-60</td>
<td>1</td>
<td>Pen: 3 ml, 300 unit</td>
</tr>
<tr>
<td>Detemir</td>
<td>3-4 hr</td>
<td>Nearl y flat</td>
<td>Up to 24 hr</td>
<td>10 mL, 1000 unit</td>
<td>Flextouch: 1-80</td>
<td>1</td>
<td>Pen: 3 ml, 300 unit</td>
</tr>
<tr>
<td>Glargine (U100)</td>
<td>3-4 hr</td>
<td>Nearl y flat</td>
<td>Approx 24 hr</td>
<td>10 mL, 1000 unit</td>
<td>Solostar: 1-80</td>
<td>1</td>
<td>Pen: 3 ml, 300 unit</td>
</tr>
<tr>
<td>Lantus/Basaglar</td>
<td>6 hr</td>
<td>Flat</td>
<td>24-30 hr</td>
<td>N/A</td>
<td>Solostar: 1-80</td>
<td>1</td>
<td>Pen: 1.5 ml, 450 unit</td>
</tr>
<tr>
<td>Degludec (U100)</td>
<td>1 hr</td>
<td>Flat</td>
<td>24-30 hr</td>
<td>N/A</td>
<td>Flextouch: 1-80</td>
<td>1</td>
<td>Pen: 3 ml, 300 unit</td>
</tr>
<tr>
<td>Tresiba</td>
<td>1 hr</td>
<td>Flat</td>
<td>24-30 hr</td>
<td>N/A</td>
<td>Flextouch: 1-80</td>
<td>2</td>
<td>Pen: 3 ml, 600 unit</td>
</tr>
</tbody>
</table>

Ultra-Long-Acting Insulins

Key Features:
- Flatter profile
- Longer duration
- Less hypoglycemia
- Once daily dosing

### Bolus Insulins

<table>
<thead>
<tr>
<th>Preparation</th>
<th>Action Onset</th>
<th>Peak</th>
<th>Action Duration</th>
<th>Vial</th>
<th>Disposable Pens and Pen with Cartridges</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Dosing Range per injection (Unit)</td>
</tr>
<tr>
<td>Bolus Insulin</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular</td>
<td>30 min</td>
<td>2-4 hr</td>
<td>6 hr</td>
<td>10 mL, 1000 unit</td>
<td>Kwikpen: 1-60</td>
</tr>
<tr>
<td>Aspart</td>
<td>15 min</td>
<td>1-2 hr</td>
<td>4 hr</td>
<td>10 mL, 1000 unit</td>
<td>Echo: 0.5-30</td>
</tr>
<tr>
<td>Novolog</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td>Flextouch: 1-60</td>
</tr>
<tr>
<td>Glulisine</td>
<td>15 min</td>
<td>1-2 hr</td>
<td>4 hr</td>
<td>10 mL, 1000 unit</td>
<td>Solostar pen: 1-80</td>
</tr>
<tr>
<td>Admelog</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lispro (U100)</td>
<td>15 min</td>
<td>1-2 hr</td>
<td>4 hr</td>
<td>10 mL, 1000 unit</td>
<td>Luxura: 0.5-30</td>
</tr>
<tr>
<td>Humalog</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Kwikpen/Solostar: 1-60</td>
</tr>
<tr>
<td>Admelog</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Kwikpen: 0.5-30</td>
</tr>
<tr>
<td>Lispro (U200)</td>
<td>15 min</td>
<td>1-2 hr</td>
<td>4 hr</td>
<td>N/A</td>
<td>Kwikpen: 1-60</td>
</tr>
<tr>
<td>Humalog</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Flextouch: 1-60</td>
</tr>
</tbody>
</table>

- Less hypoglycemia with insulin analogs compared to regular human insulin

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### OSU Rapid Acting Insulin Order Panels

<table>
<thead>
<tr>
<th></th>
<th>Approximate total daily dose</th>
<th>I:CHO</th>
<th>Supplemental</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt;20 unit</td>
<td>1 unit/20 gm</td>
<td>1 unit/100 mg/dl</td>
</tr>
<tr>
<td>Standard</td>
<td>20-60</td>
<td>1 unit/10 gm</td>
<td>1 unit/50 mg/dl</td>
</tr>
<tr>
<td>High</td>
<td>60-100</td>
<td>1 unit/5 gm</td>
<td>1 unit/25 mg/dl</td>
</tr>
</tbody>
</table>

Insulin:Carb ratio = 500/total daily dose of insulin
Supplemental (correction) factor: 1 unit per (1500/total daily dose) mg/dl
Timing of Insulin Doses in the Hospital

**Inter-dose correction interval**
CBG should be measured >3 hours after last insulin dose

**CBG-meal interval**
CBG should be pre-meal

**Meal-dose interval**
Insulin dose should be 30 minutes before/after meal

**CBG-dose interval**
CBG should be <1 hour before correction insulin dose

CBG=capillary blood glucose

Dungan KM. Curr Diab Report 2019

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Should Non-Insulin Agents be Discontinued Inpatient?

*Factors to influence decision:* short hospital stays, previous good control, no contra-indications
- DPP-IV inhibitors well tolerated but have limited efficacy.
- Continue home weekly GLP-1

<table>
<thead>
<tr>
<th>Caution</th>
<th>MTF</th>
<th>SFU</th>
<th>TZD</th>
<th>DPP-4i</th>
<th>SGLT2i</th>
<th>GLP-1 RA</th>
<th>Insulin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kidney disease</td>
<td>Risk of lactic acidosis</td>
<td>Prolonged hypoglycemia</td>
<td>Fluid overload</td>
<td>Adjust dose</td>
<td>Fluid shift</td>
<td>GI side effects → fluid status</td>
<td>Reduced clearance</td>
</tr>
<tr>
<td>Hypoglycemia</td>
<td>N</td>
<td>Y</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>N</td>
<td>Y</td>
</tr>
<tr>
<td>Other</td>
<td>GI side effects</td>
<td>Lactic acidosis (IV contrast)</td>
<td>Heart failure</td>
<td>?Pancreatitis</td>
<td>GU infection DKA</td>
<td>GI side effects ?Pancreatitis</td>
<td></td>
</tr>
<tr>
<td>Examples</td>
<td>Metformin</td>
<td>Glimepiride</td>
<td>Glipizide Glyburide</td>
<td>Pioglitazone</td>
<td>Sitagliptin</td>
<td>Linagliptin Saxagliptin Allogliptin</td>
<td>Empagliflozin Canagliflozin Dapagliflozin Ertugliflozin</td>
</tr>
</tbody>
</table>

MTF=metformin, SFU=Sulfonylureas, TZD=thiazolidinediones, GLP-1 RA= Glucagon-like Peptide-1 Receptor agonist, SGLT2i=Sodium-Glucose Cotransporter-2 inhibitor.
What to do for a Procedure

• As a general rule DO NOT HOLD basal insulin
  – Consider reducing by 20-50%, especially if there is suspicion that it is being used for prandial coverage (basal insulin >50% of total daily insulin dose)
• Do hold meal time insulin

*Under no circumstances should you withhold basal insulin from a patient with Type 1 Diabetes!

Pulsed Steroid Dosing

• Difficult to control
• Treatment
  – Insulin drip
  – NPH 0.5 units per 1 mg of prednisone is an option
  – Increase prandial insulin (e.g. 1:10 → 1:5)
  – If NPO use regular insulin for correction every 6 hours
• Preemptively reduce insulin in anticipation of reduction in steroid dosing

What to do if a patient is admitted with on an insulin pump?

Presenting in DKA?
- Yes
  - DKA Guideline
  - Disconnect pump
  - If concern for malfunction, have patient call manufacturer
- No

Is patient able to operate pump independently?
- Yes
  - Diabetes Consult
    - Confirm appropriate for pump
    - Use temp basal rate if needed
    - Place orders for inpatient use
- No
  - Order alternate form of basal insulin (glargine/IV)

Nurse
- Document all boluses (in units)
- Document all carbs
- Document infusion site
- Treat hypoglycemia like any other patient. Do not remove pump

Patient
- Record all carbs and inform nurse
- Record all boluses and inform nurse

Glucose Testing

- Glucometers typically have approval for hospital use for venous and arterial specimens
- Capillary use MAY not be intended for those that are critically ill
  - Capillary whole blood specimens (e.g. obtained by finger stick) should not be used in patients receiving intensive medical intervention/therapy...
    - Examples include...severe hypotension, shock, hyper-osmolar-hyperglycemia (with or without ketosis), and severe dehydration.
Hypoglycemia

A hypoglycemia management protocol should be adopted and implemented by each hospital
Each patient should have an established plan for treating hypoglycemia
Hypoglycemia should be tracked and documented in the medical record

OSU Hypoglycemia Treatment Guideline

Table 1. Patients Who Are Alert with Available External Access and Intact Cognitive Status

<table>
<thead>
<tr>
<th>Blood Glucose (mg/dl)</th>
<th>Action</th>
<th>Follow Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>60-69 mg/dl</td>
<td>Next meal less than 1 hr (15 g oral carbohydrate, choose one)</td>
<td>Recheck BG q15 min and treat accordingly until BG &gt;80 mg/dl</td>
</tr>
<tr>
<td></td>
<td>4 oz juice or regular soda</td>
<td>Once BG &gt;80 mg/dl, recheck BG q15 min x 2, then resume point-of-care glucose as previously ordered</td>
</tr>
<tr>
<td></td>
<td>1 tsp jelly or sugar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 glucose tablets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 tube dextrose gel</td>
<td></td>
</tr>
<tr>
<td>45-59 mg/dl</td>
<td>Next meal less than 1 hr (15 g oral carbohydrate, choose one)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 oz juice or regular soda</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 tsp jelly or sugar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 glucose tablets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 tube dextrose gel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Call House Officer to report BG and action taken</td>
<td></td>
</tr>
<tr>
<td>&lt;45 mg/dl</td>
<td>Next meal less than 1 hour (30 g oral carbohydrate, choose one)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4 oz juice or regular soda</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 tsp jelly or sugar</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5 glucose tablets</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 tubes dextrose gel</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Call House Officer to report BG and action taken</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Next meal 1-2 hrs (choose one)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 graham crackers</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6 oz skim milk</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Call House Officer to report BG and action taken</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Next meal more than 2 hrs (choose one)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1 sandwich (30 g)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 graham crackers with one tsp peanut butter</td>
<td></td>
</tr>
</tbody>
</table>

*Treat based upon BG level
Recheck Q15 min until BG >80 mg/dl

Risk Factors for Inpatient Hypoglycemia

<table>
<thead>
<tr>
<th></th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>DM</td>
<td>2.6</td>
<td>1.5-4.7</td>
</tr>
<tr>
<td>Sepsis</td>
<td>2.2</td>
<td>1.2-4.1</td>
</tr>
<tr>
<td>↓CHO Intake</td>
<td>6.6</td>
<td>1.9-23</td>
</tr>
<tr>
<td>Inpatient Insulin use</td>
<td>5.4</td>
<td>2.8-10</td>
</tr>
<tr>
<td>Shock</td>
<td>1.8</td>
<td>1.1-2.9</td>
</tr>
<tr>
<td>Prior History of Hypoglycemia</td>
<td>2.3</td>
<td>1.1-4.7</td>
</tr>
</tbody>
</table>

Reduce insulin, increase monitoring if
• Any form of carbohydrate is interrupted
• In setting of declining renal or hepatic function


Discharge Planning
Discharge Planning

- There should be a structured discharge plan tailored to the individual patient with diabetes
- Perform an A1c on all patients with diabetes or hyperglycemia admitted to the hospital (if not done in the prior 3 months)

ADA/AACE Recommendations

The mean hospital LOS is usually <5 days and the capacity to learn new material may be limited during acute illness. Diabetes-related education is frequently limited to an inventory of basic “survival skills.”

- Level of understanding pertaining to diabetes
- Self-monitoring of BG and home BG goals
- Definition, recognition, treatment, and prevention of hyperglycemia and hypoglycemia
- Consistent eating patterns
- When and how to properly take BG-lowering medications, including insulin
- Sick day management
- Proper use and disposal of needles and syringes
- Hospital follow-up plans

Discharge Treatment

A1C < 7%
- Sitagliptin +/- metformin and/or previous home antidiabetic agent(s)

A1C 7%-9%
- Sitagliptin +/- metformin plus glargine once daily at 50% of hospital dose or 0.1 unit/kg
- Sitagliptin +/- metformin plus glargine once daily at 80% of hospital dose or 0.2 unit/kg

A1C >9%

ADA Guidelines for Non-Insulin Therapies

- **ASCVD**
  - GLP-1RA or SGLT2i*

- **HF or CKD**
  - SGLT2i* or GLP-1RA

- **Hypoglycemia**
  - SGLT2i*
  - GLP-1RA
  - DPP-4i
  - TZD

- **Weight Gain**
  - GLP-1RA
  - SGLT2i*

- **Cost**
  - SFU
  - TZD

Other agent demonstrating CV safety:
- DPP4i (Sitagliptin, Linagliptin)

*If eGFR is adequate

Other agent
- Colesevelam
- Bromocriptine
- AGI
- *later generation SFU, Ultra-long acting basal insulin*

Other agent
- Colesevelam
- Bromocriptine
- AGI
- Minimize SFU, insulin, TZD

Other agent
- AGI
- insulin

Davies et al. Dia Care 2018:41:2669-2701
Intensifying to Injectable Therapy

GLP-1 RA
- Continue metformin +/- other agent
- Start 10 unit/day or 0.1-0.2 unit/kg/day

Consider initial combination injection if A1c > 10 or if >2% above target

Basal Insulin
- Continue metformin +/- other agent
- Start 10 unit/day or 0.1-0.2 unit/kg/day

Self-titrate

Not at goal after FBG target is reached or >0.5 unit/kg

Basal Plus
- GLP-3 RA or Fixed ratio combination
- Prandial insulin at largest meal
  - 4 unit, 0.1 unit/kg, or 10% of basal dose
  - Consider reducing basal
- Premix: Divide basal dose to 2/3 AM, 1/3 PM

Consider initial insulin if A1c > 10 or if >2% above target

Self-titrate

Basal Bolus
- Prandial insulin at 2-3 meals
  - 4 unit, 0.1 unit/kg, or 10% of basal dose
  - Consider reducing basal

Oral therapy in combination with injectable therapies

- Metformin: continue
- DPP4i: stop if using GLP-1RA
- SFU: stop or reduce dose with insulin
- TZD: stop or reduce dose with insulin
- SGLT2i: continue but beware of DKA in insulin requiring patients (provide sick day rules)
Conclusions

1. Diabetes is a very common diagnosis in the inpatient setting
2. Hospitalization provides an opportunity to identify and help improve glycemic control
3. Standard protocols help promote consistency and facilitate education
4. Transitions of care back to the outpatient setting can create challenges to glycemic control